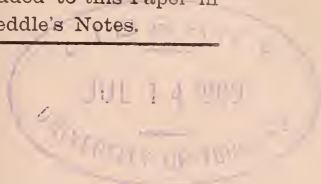


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Another Plate is proposed to be added to this Paper in
Illustration of Professor Heddle's Notes.



SEVENTH REPORT

OF THE

BOULDER COMMITTEE

OF THE

ROYAL SOCIETY OF EDINBURGH.

1881.

BOULDER COMMITTEE.

Sir ROBERT CHRISTISON, Bart.

Sir CHARLES WYVILLE THOMSON, LL.D.

Rev. THOMAS BROWN, Edinburgh.

ANDREW FLEMING, M.D., Edinburgh.

Professor ARCHIBALD GEIKIE, Edinburgh.

Professor FORSTER HEDDLE, St Andrews.

WILLIAM JOLLY, School Inspector, Inverness.

ARTHUR MITCHELL, M.D., Edinburgh.

RALPH RICHARDSON, Edinburgh.

THOMAS STEVENSON, C.E., Edinburgh.

General BAYLY, 58 Palmerston Place, Edinburgh.

Professor DUNS, D.D.

DAVID MILNE HOME, LL.D. (*Convener*).

SEVENTH REPORT
OF THE
BOULDER COMMITTEE
OF THE
ROYAL SOCIETY OF EDINBURGH.

(WITH TWO PLATES.)

*From the Proceedings of the Royal Society of Edinburgh,
Session 1880-81.*

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SEVENTH REPORT

OF THE

BOULDER COMMITTEE OF THE ROYAL SOCIETY OF EDINBURGH.

NOTES BY CONVENER.

ARGYLESHIRE—CRINAN CANAL.

1. Between Crinan Bay on the north and the head of Loch Fyne on the south, there is a trough or hollow now occupied by the Crinan Canal. The highest point along this trough, is about 150 feet above the sea. A series of locks occur at this summit-level, to allow of the passage of vessels between the two sea-lochs.

At the summit-level, the rocks form a sort of ridge across the valley, with smooth surfaces towards the north, and rough surfaces towards the south.

On both sides of this rocky ridge, there are large boulders; on the north side, I counted between forty and fifty, on the south side, there are not more than two or three. The boulders are a syenitic gneiss; the rocks *in situ*, are shivery clay slate, nearly vertical, dipping steeply towards the south.

Three or four of the boulders on the north side, I found pressed or squeezed up against the rocks *in situ*, in such a way as to show that they had come from the north, and had been obstructed in their farther progress southwards by the rocky ridge. In one case, the boulder lies with its longer axis N.N.W., which is about the direction of the valley at this place. There is a hollow on the north side of the ridge, as if made by the force with which the boulder had been pushed or driven against it. Other two

boulders were in size $10 \times 5 \times 4$ feet, with the longer axis W.N.W., and $9 \times 5 \times 4$ feet, with longer axis and sharpest end due north. Many others were blocked in a similar manner.

The boulders on the south side of the ridge, are of much the same size, but are not close to the ridge; they may have tumbled over the ridge by falling from the agent which brought them when it stranded on the ridge. The spot now referred to, adjoins the small stream which flows down from the tanks for supplying the Crinan Canal. These tanks a number of years ago burst, and many large fragments of rock came down with the torrent, but these are quite distinguishable from the boulders above mentioned.

In reference to the agent which may have brought these boulders from the north, there is nothing to suggest the action of a glacier, as the trough forming the bed of the Crinan Canal, towards the north, unites with an arm of the sea at the distance of only about 2 miles. That at some former period of the earth's history, this Crinan Canal trough was occupied by the sea, through which floating ice might flow, is evident from the well-known traces of old sea-margins visible on the adjoining coasts up to at least 300 feet above the present sea-level. At the summit-level in this Crinan Canal trough, the width of the valley is narrower than anywhere else—probably not more than 300 yards, so that floating ice passing through this Kyle would easily choke there.

Mr Jamieson, in one of his papers published in the London Geological Society's Journal, alludes to this trough, now the bed of the Crinan Canal, and states that he found smoothed rocks on the east side of the valley, and strictions running N.W. and S.E. I did not see these markings. They are not inconsistent with the theory above suggested as to the transport of the boulders.

2. *Oban*.—At the south end of the town there is a large number of huge blocks of the Old Conglomerate rock, which forms high and steep cliffs both east and south of the town.

On Plate I. there is a sketch of the district occupied by the town and by a portion of the hills to the east and south, copied from the Ordnance Survey Map. The cliffs on the east side of the town (A B C) have nearly vertical fronts, facing the sea. They reach to a height of from 120 to 150 feet above the sea-level. At C these cliffs take a sudden turn to the eastward. The rocks at B C are a

coarse red conglomerate, which face about due west. At E F there are hills reaching to a height of 300 feet above the sea. Between the cliffs B C and the hills E F, the distance is about one-third of a mile, and the ground between is so flat that the sea at spring tides flows on to it. There is a meadow up to Dunans, the surface of which nowhere exceeds 20 feet above the sea. At Dunans, however, there is a knoll of conglomerate rock, the top of which reaches to a height of 212 feet above the sea.

The buff-coloured asterisks ($\times \times$) indicate spots where boulders occur. It will be perceived that they abound on the hill-slopes at H and K facing the N. and N.W. They are almost all grey granite, pretty well rounded, and having a diameter from 5 to 7 feet. One boulder out of about twenty which I examined, was of porphyry, with white felspar crystals in a basis of purple alumina.

In the meadow or valley to the north of the hills G H K many boulders of grey granite are lying about. The largest I found was on Dunans Knoll, and on the side of the knoll facing N.W. To the south of the conglomerate cliffs at C, there is a *trainée* of conglomerate boulders, evidently derived from these cliffs. They form a line running about S.E. ; most of them are about 80 or 100 yards from the cliff, and one or two occur in the low ground about 200 yards from the cliff.

Some of these boulders are buried in a mass of gravel (as shown in Plate I.) 10 or 12 feet thick, lying on the edges of the vertical strata of dark-coloured clay slate. The pebbles in the gravel are chiefly grey granite and gneiss. There is a quarry at this place which shows well, a section of the gravel. In another part of the quarry, there is a bed of laminated clay, 4 feet thick, lying between the rocks and the gravel. The workmen in the quarry informed me, that they had seen shells in this clay bed, but I was unable to reach the bed to search for shells, on account of its inconvenient position.

One of the conglomerate boulders lies against a rocky knoll A, which has apparently obstructed the progress of the boulder farther south. Several others lie to the S.E., in the meadow, as if tumbled off the agent, whatever it was, which carried them.

The new railway from Oban to Dalmally cuts through a portion of the hill composed of dark blue slate rocks (see F, Plate I.).

Over these rocks lies a bed of boulder clay containing granite boulders. One which I found undisturbed, measured $5 \times 3 \times 3$ feet, with its longer axis pointing N. by E. and S. by W.

On walking over the hills E F (Plate I.), situated above Professor Blackie's cottage, I fell in with a valley about three-quarters of a mile long, opening towards the north. The bottom of the valley is about 80 feet above the sea, with hills on each side reaching to about 300 feet, and blocked at its south end by a range of hills about 600 feet above the sea. In this valley, I found two or three granite boulders, from 3 to 4 feet in diameter, on the east side of the valley, at a height of about 120 feet above the sea, lying on slate rocks. These granite boulders could not have come into this valley except from the north. The width of the valley is from 300 to 400 yards. From the peculiar position of the boulders on the east side of the valley, it may be very probably inferred, that they had come from some north-westerly point.

The sides of the valley where these boulders lie, are at present exceedingly steep, and it seemed marvellous that if they fell on the surface where they now lie, they did not roll to the bottom. It occurred to me that probably when these boulders arrived, the valley was filled with gravel, and that as the gravel was scoured out by streams, the boulders slowly subsided to their present positions.

On the west side of the valley, there is another grey granite boulder, at a level about 30 feet higher than the site of those just mentioned. It is $4 \times 3 \times 3$ feet, and with its longer axis pointing N.N.E.

At the north end of Oban Bay, the grey granite boulder is situated, which was mentioned in last year's Report (p. 11). Its position is indicated on Plate I. by the buff-coloured asterisk near the letter A. Its position close to the high conglomerate cliff raises a presumption that it had come from the westward, and had been intercepted in its farther progress by the cliff. This is strengthened by the fact mentioned in last year's Report, that its longer diameter points W. by N. It probably came by the same agency, whatever that was, which brought the other grey granite boulders shown in Plate I.

I examined the small island in Oban Bay opposite to Professor Blackie's cottage, near the east side of Kerrera Island (L in Plate I.).

Professor Duns having landed on this island in a previous year, had noticed several boulders, and suggested that I should visit it. I found on it four or five grey granite boulders, the rock of the island being entirely conglomerate. One or two of the boulders were in positions indicating probable transport from the north.

I proceeded next round the north end of *Kerrara Island* as far as Bal-na-bok Bay, landing, on my way there, at parts of the shore where boulders were observable. At the north end of Kerrara, where the rocky cliffs of conglomerate reach a height of about 100 feet, I found four or five large boulders of granite, all grey but one, which was red. Their position close to these high cliffs suggested that they had come from some northern point, and had been intercepted there.

On a small island near the same place, there is a grey granite boulder, $8 \times 5 \times 4$, and in such a position as also to indicate transport from the north.

On reaching Bal-na-Bok, I found the shepherd and his daughter (M'Kinnon) very willing to guide me across the hills, and point out a number of boulders known to them. Accordingly, in the course of a three hours' circuit among hills about 300 feet above the sea, I examined about twenty boulders, all granites except one, which was a greenstone. Some of the granites had a pinkish tinge of colour. Most of the boulders were lying with their longer axis N. and S., but there was nothing in their positions to show from which quarter they had come.

The late Robert Chambers (Edin. New Philosoph. Journal for 1853, p. 254), mentions having seen in Kerrera Island, "numerous smoothed (rock) surfaces dipping into the sea, with striations from N. 60° W., being nearly the same direction as Mr Maclaren's W.N.W." I did not fall in with any of these. He mentions "that on the high grounds above Tobermory, in Mull, there are striæ pointing from N. 60° W."

3. Having been informed of there being a large boulder on the hills on the south side of the road between Oban and Connal Ferry, on the farm of *Dumbeg*, I called on Mr Brown the tenant, and induced him to guide me to the place. The hills here face the north, and the boulder was on one side of a niche in this range of hills.

Its position between the hills is indicated by $\times$ on the annexed diagram (fig. 1), which shows the ground plan of a narrow valley,

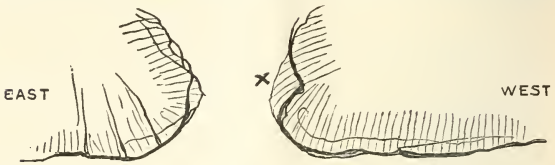


Fig. 1.

open at each end, about 500 yards in length, about 50 yards wide, and with sides from 200 to 300 feet high. Fig. 2 shows a section

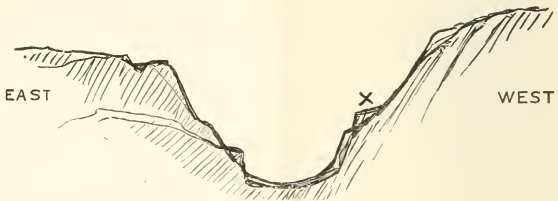


Fig. 2.

across this valley, with the boulder on the west side, upon a shelf, at the height of about 250 feet above the sea. The boulder measures $11 \times 6 \times 5$ feet, and the longer axis points N.N.W. and S.S.E.

The axis of the valley, which rises to the south, is N.W. and S.E.

The rocks here are clay slate, the boulder is grey granite.

In reference to the transporting agent, it is almost certain that the boulder must have been brought into the valley, by either its north or its south end.

From the boulder, Ben Cruachan is visible, bearing E.S.E. at a distance of about 10 miles. If a glacier be thought of to bring it from Cruachan, there are hills and valleys in the way, rendering the course of a glacier along that line most improbable. The more natural course of a glacier would be down Loch Etive. On the other hand, there seems to be nothing improbable in the supposition, that it may have been brought by floating ice from the north.

In making a short tour across the adjoining hills, I found many other boulders of grey granite, and mostly on hill slopes facing the north. One of these boulders, $6 \times 4 \times 4$ feet, was in the position shown in the annexed diagram, fig. 5, Plate III., which represents a slope of the hill, facing N.W. The boulder lay on a sort of shelf blocked at its S.E. end.

4. At *Dunstaffnage*, about 5 miles N.E. of Oban, there is a conglomerate rock on which the old castle stands, as shown on fig. 3.



Fig. 3.

The rock at the west end is about 30 feet above the general level of the land, and it extends horizontally for about 50 yards. On its east side the rock, though extremely tough, and full of large pebbles of quartz and other hard rocks, has been well smoothed by some agent of great weight and power which has come from the eastward.

The conglomerate rocks on the beach below the castle, present similar smooth surfaces facing the east.

Having learnt from the keeper of the castle, that smooth rock surfaces occur on a small island a few hundred yards to the east of Dunstaffnage, I procured a boat, and found two high knolls of conglomerate rock, as shown in fig. 4, smoothed in a similar manner.

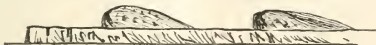


Fig. 4.

In going along the south bank of Loch Etive, one sees at numerous places great sheets of similarly smoothed rock, indicating, apparently, the action of a glacier which had moved down the valley now occupied by the loch. In the Fifth Report of the Committee (page 45), notice is taken of the Airde Point, on the west side of Loch Etive, where the rocks facing the south, *i.e.* up the glen, were found smoothed up to a height of 276 feet above the sea.

In passing along the new line of railway, between Oban and Loch Awe, one can notice many smoothed rocks, all like those before-mentioned, facing Loch Awe. A number of these smoothed rocks are covered by beds of fine gravel, sections of which, showing rock and gravel, are well seen on both sides of the railway which cuts through them. The best examples are near the village of Stonefield, to the east of Connal Ferry. The height above the sea here is about 40 feet, and traces of the well-known sea-terrace, so prevalent around the coast, are here observable. As one advances towards Taynuilt and Bridge of Awe, the detritus occurs in larger quantities. At Bridge of Awe it forms mounds, which are no doubt due to the removal of other portions of the detritus by the rains and streams descending the steep sides of Cruachan on the one side, and of the hills on the opposite side of the Etive valley. The Awe itself has on its banks, scours of detritus 20 to 30 feet in depth, and there are marks showing that the river has run in a different course and at a higher level.

The whole of this valley is full of boulders of granite, mostly grey, but occasionally red. These boulders generally lie on the detritus, and in many cases are covered by peat which has grown in the pools, or what had been pools, in the detrital hollows.

On ascending the hills on the west side of Bridge of Awe, which I did to the height of about 400 feet above the sea, I found boulders, especially on the slopes facing the north and east. They may, no doubt, have crossed the valley from Cruachan. I measured several of the largest, which were 5 or 6 feet in length by 3 or 4 feet in width and height. There were among them small boulders of well-rounded quartzite, which suggested a northern origin.

The large granite boulder on the roadside between Taynuilt and Bridge of Awe, nicknamed Sir Walter Scott, lies on detritus.

5. *Loch Sweyn*.—Having heard of some large-sized boulders in this neighbourhood I went there, accompanied by Mr Alexander of Loch Gilp.

At Ardna, on the farm of Mr Middleton, near Kilmory Bay, I examined a surface of smoothed slate rocks, covered by long and deep striations running W. by S. and E. by N. Unfortunately I omitted to observe from what direction the striating agent had moved, but as the smoothed surface of the rock sloped

down towards the west, it is probable that the striating agent had come from the west.

On this smoothed and striated rock, there were large boulders of grey granite; I measured two, of the following dimensions, viz., $15 \times 12 \times 5$ feet and $13 \times 5 \times 5$ feet. Their longer axis was the same, viz., W.S.W. It is proper to remark, that the sea-lochs in this part of the coast occupy troughs which lie in a direction W.S.W. and E.N.E., and that the ridges of land which separate these lochs run in a similar direction.

The boulders and striated rock just mentioned are on the S.E. side of the ridge which divides Loch Sweyn from Loch Killesport. But on crossing the ridge north towards Loch Sweyn, I found most of the boulders on the hill slopes which face the N.W. all lying in the same manner, viz., with their longer axis parallel to the loch and to the ridge of high ground. On *this* slope, the boulders are in *thousands*. I measured a few of the largest,—one was 15 feet square and 8 feet high, another $18 \times 7 \times 5$ feet. The ridge between the two lochs rises gradually to the eastward inland to a height of from 500 to 700 feet.

In this district I saw no detritus. If there ever had been detritus it had been swept off, as the rocks *in situ* were everywhere visible, and the boulders were lying mostly on the bare rock. Of moraines I saw no appearance. Sitting on this hill slope, and pondering from what quarter these boulders in such numbers could have come, it appeared to me that, in order to reach and remain on this hill slope, they could only have come from the N.W. If the agent which brought them, had come *down* the loch from the N.E. there was nothing to cause them to stop and remain where they now are;—they would have gone on towards the open sea at the lower end of the loch. If they had come from the S.W. there was nothing to obstruct their further progress up the loch.

In walking further up the loch, Mr Alexander and I passed a rock surface, pretty steep, and sloping down southwards, on which there were many deep striæ running W.S.W. and E.N.E., parallel with the general axis of the valley. The striating agent seemed to have come up the loch. This was at a place named on the Ordnance Map "*Doide*." Here we obtained a boat and crossed over to *Dinna Island*, to examine a large boulder which gives its name to the farm "*Danna na Cloiche*."

The boulder would be of the shape of a pear, were a horizontal section made through its widest part (fig. 6). Its sharpest end



Fig. 5.

points S.W. Its height is about 15 feet, and it has three sides tolerably flat, each about 15 feet wide. I calculated its weight at from 60 to 70 tons.

Its axis coincides with the general direction of the valley, and its sharpest end is towards the sea, creating a presumption that something floating up the loch may have put it and left it in that position.

The boulder is nearly opposite to Castle Sweyn, which is on the south bank of the loch. There is a rocky knoll about 40 feet above the loch on which the castle had been built. On the west side of this knoll there is a great number of huge angular boulders, which seem to have come from the westward, and been intercepted by the knoll in their progress eastwards. The narrowest part of the loch is at Castle Sweyn, so that it was the most likely place for an obstruction of ice rafts from the west.

6. *Ardrishraig*.—In ascending the hill to the west, on the lands of Auchindarroch, accompanied by Mr Alexander of Loch Gilp, I had pointed out to me by him a gneiss boulder, $9 \times 7 \times 6$ feet, lying on a smoothed rock of clay slate. Its longer axis lay N. and S., its sharpest end being to the north. Another boulder, somewhat higher up, was seen, $16 \times 13 \times 6$ feet, with its axis also N. and S. The slope of the hill here is down towards the S.E. These were at a height of about 300 feet above the sea.

On going higher up the hill and coming to a slope down towards N.N.E., I fell in with many other boulders of such sizes as the

following— $9 \times 7 \times 6$ feet, $8\frac{1}{2} \times 7 \times 4$ feet. These two were on the same slope, and one above the other, at a distance of about 15 yards, as shown on fig. 6, Plate III. They must certainly have come from some northern point.

BERWICKSHIRE.

In July 1880, I was requested by Captain Norman, R.N., to examine some boulders which he had discovered in a ditch on a roadside situated about a mile to the north of Berwick-on-Tweed.

Having accompanied him to the spot, I found four boulders, each weighing from half a ton to one ton. Two of the boulders were of fine-grained granite,—one of them grey in colour, and the other with a shade of pink. They had most probably come from Cockburn Law, situated about 15 miles (as the crow flies) to the N.W. Both colours of granite occur in that hill and a lower spur called Stanchol. The other two boulders were a dark porphyry. Lamber-ton Hill, situated to the N. and N.N.W., about 2 miles off, is composed of porphyry of several varieties. The site of these boulders is about 250 feet above sea-level.

BUTE.

1. J. Miller, C.E., Glasgow, having, during the last two years, had occasion to be frequently in Bute, and having taken notes of the boulders lying about the coast near *Rothsay*, and to the north of it, had the kindness to draw out for the Committee the following list of boulders observed and studied by him.

(1.) On the shore to the east of *Rothsay*, at Glenburn, a chlorite schist boulder $6 \times 5 \times 5$, with large grains of quartz, weighing probably about 7 tons. It rests on the red conglomerate of this part of the island.

(2.) Near Craigmores pier, east of *Rothsay*, about 30 feet above sea-level, a boulder of very coarse pebbly schist, about $3\frac{1}{2}$ feet long, well rounded and smoothed on lower side. It was near the mouth of a disused whinstone quarry, among conglomerate gravel.

(3.) Farther east, and south of a point of land a little below high-water mark, there is a boulder of trap, 6 feet long, resting on red conglomerate rocks.

(4.) On ascending the hill from the last-mentioned place, several

micaceous schist boulders are met with, two measuring about 3 feet across, one about 70 feet, and the other 120 feet above sea-level.

(5.) Still farther up the hill, and on road towards Rothesay through a wood, at 150 feet above sea-level, there are many schist boulders, well rounded and smoothed, some about 3 feet in length.

At 180 feet above sea-level, there is a coarse schist boulder $5 \times 2\frac{1}{2}$ feet, one end round and smooth, the other end rough and angular—longer axis E.N.E. by compass.

(6.) Nearer Rothesay, on same road, at about 200 feet above sea-level—a mica schist boulder, about 6 feet long, rounded at one end and rough at other end.

(7.) In great sandpit above and behind Queen's Hotel, Rothesay, a mass of coarse gravel lies above sand, forming a bed about 12 feet thick. The underlying sand is of unknown depth, but a face of it is seen for about 30 feet vertically, with a length of about 200 yards. Several boulders of gneiss occur in the sand, the largest about $5 \times 3 \times 2$ feet. North-west of this sandpit, and near it, there is a smoothed rock about 120 feet above sea-level. As its smoothed surface looks northwards, the smoothing agent must have come from some northerly point.

(8.) At Ardbeg, north of Rothesay, there are many boulders on the shore—one $9 \times 8 \times 5$ feet, another $10 \times 7 \times 5$ feet; one is quartz or chlorite schist, the other trap. The rocks *in situ* are chloritic slate, dipping S.E. 56° . First-mentioned boulder has its longer axis pointing N.W. and S.E.

(9.) In Port Bannatyne Bay, there are hundreds of boulders on the shore seen at low water, all well rounded. Those which are long shaped generally lie S.E. and N.W.

Near the head of Port Bannatyne, in a field about 30 feet above sea-level, there is a coarse schist boulder $4 \times 2 \times 2$ feet, one side finely smoothed, with ruts on it parallel to longer axis.

(10.) At Ardnaclich Point (entrance to Kyles of Bute) there are many schistose boulders, some coarse and pebbly, others fine-grained. The largest is $8 \times 8 \times 6$ feet. They lie on blue slate rocks.

(11.) At north end of Bute, opposite to Colintrave, the rocks, up to 230 feet above sea-level, are rounded and smoothed. They consist of mica schist, in some parts coarse and pebbly. Some of them quite resemble the boulders at and near Ardnaclich Point.

At 380 feet above sea-level, the rocks are smooth on their sides facing the N.W., but rough and fissured on their eastern sides. Blocks lie below them on these east sides.

(12.) Around Bute Loch, the rocks, at 560 feet above sea-level, are well smoothed, and form a steep wall facing N.W.

(13.) Notes applicable to district from 3 to 6 miles south of Rothesay :—

(a.) *Ascog Loch*, about 100 feet above sea-level; at north-east end, a great number of schistose boulders; at north-west end, a large quantity of schistose stones. The rocks *in situ* here are red conglomerate.

(b.) *Loch Fad*.—On the N.W. of this loch, there is a hilly range running N.E. and S.W., and reaching heights of from 400 to 450 feet above sea-level. In one part, there is a gorge through which something has passed, smoothing and striating the rocks. The striæ point S.E. and N.W. On the south slopes of this range, lie a number of blocks which seem to have been transported, being too distant from any cliffs from which they could have fallen by mere gravitation.

To the south of this hilly range, and perhaps an extension of it, there is a hill (not named in Ordnance Map) about 480 feet high on the north side of *Dhu Loch*. This hill on its north side presents rock-surfaces, rounded and smoothed. On its south slopes there are boulders, two of which I measured, viz., $6 \times 5 \times 2$ feet, and $6 \times 4 \times 2$ feet.

Close to *Dhu Loch*, there is another boulder, $6 \times 5 \times 4$ feet, at about 320 feet above the sea.

The rock composing these boulders is apparently similar to that of the hills to the south of which they lie. What occurred to Mr Miller was, that they had been riven from the rocks of these hills by some agent, which passed over and across them from the north.

2. The Convener having in October last gone to *Rothesay* for a few days, examined several of the boulders on the east coast, mentioned by Mr Miller in the foregoing notes :—

One day was devoted, in company with Mr Miller, to a portion of the *West Coast north from Ettrick Bay*. A great many large boulders were found along the shore, all showing transport from the north-west.

In Ettrick Bay itself there are only a few boulders, and these are situated at the north side of the bay. The coast to the north of the bay runs in a line about N.N.W. by compass. To the south of that bay the coast-line runs about S.S.W. The position of the boulders is indicated on the annexed diagram (fig. 6) by $\times \times \times$.

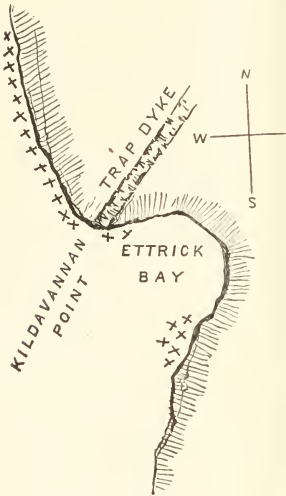


Fig. 6.

At the north end of Ettrick Bay, there is a compact ridge of rock, a sort of trap dyke, which stands from 10 to 15 feet above the adjoining surface of the land with vertical walls. The public road runs along the coast both north and south from Ettrick Bay, so that there is ample opportunity of studying the boulders lying on the shore.

At or very near Kildavannan Point a boulder of pure quartz first attracted attention, $6\frac{1}{2} \times 5\frac{1}{2} \times 4$ feet, weighing about 10 tons. From the way in which it was blocked on its east side, it seemed to us probable that the parent rock

would be found to the west. Accordingly, at a distance of about 100 yards, a very large mass of quartz rock was found *in situ* among the slate rocks.

The boulder next met with was one of gneiss, $11\frac{1}{2} \times 7 \times 5$ feet, weighing about 30 tons. Its sharpest end pointed N.N.W. There was vertical slate rock under its east end, which seemed to have obstructed its progress eastward (see fig. 3, Plate III.).

There was another gneiss boulder $8 \times 7 \times 6$ feet, also on slate rocks, and blocked in a similar manner at its east end.

At one place the slate rocks, which are nearly vertical, and running in a direction about S.W. and N.E., presented a vertical wall on the beach of several feet in height, facing the north; a gneiss boulder, $12 \times 8 \times 5$ feet, weighing about 35 tons, rested against this

north wall in such a way as to show it had been pushed from the north, and had been stopped by the rock. A number of smaller gneiss boulders were on the beach close to the north side of the slate rocks (see fig. 4, Plate III.).

Many more examples of the same kind were observed along the coast for about 3 miles. The boulders are larger in size towards the north.

On returning back to Ettrick Bay, a visit was paid to the coast, on the south side of the bay. It has been already mentioned that in Ettrick Bay, on the shore, there are no boulders, but to the south of the bay they again occur, most of them gneiss, though there are also some of granite. A sea-wall, lately built to protect the high road, contained a large number gathered off the shore, and others were showing their heads above water at a distance from the shore. The same agent which had carried or pushed the boulders along the coast north of Ettrick Bay, had continued its S.S.E. course across the mouth of the bay, and dropped boulders on the coast beyond the bay. The high ridge of rock at Kildavannan Point, before referred to, had probably to a certain extent protected the bay from any influx of boulders. If the transport of the boulders was due to ice floating on a current of the sea from N.N.W., this may have occurred when the sea stood several hundred feet above its present level, in which case the Kildavannan ridge might still have acted in the way now suggested, as it runs up the land, in a north-easterly direction, to a considerable distance.

All along the part of the west coast just described, the 40 feet old sea-margin is exceedingly distinct. Those at higher levels, seen elsewhere on the West Coast of Scotland, were not observed in this part of Bute.

3. On the following day the Convener, under the guidance of Mr Miller, paid a visit to *Barone Hill*, situated about 3 miles to the S.W. of Rothesay, and reaching to a height of about 530 feet above sea-level. Plate II., fig. 2, gives a sectional outline of the hill in an east and west direction. The hill was first approached by us from the eastward, and there was a close examination of the bare rocks on the north side in search of smoothed faces. One or two were found, though not of so decided a character as to deserve special notice. Beyond the principal hill, about half a mile farther west, there is

another hill, reaching a height of about 430 feet, with a gully between the two, on which Mr Miller discovered markings of a very interesting character, and called to me to come and examine them. This gully is about 30 yards wide, having sides of bare rock more or less vertical—the rocks on the east side higher than on the west side. On entering this gorge (A figs. 2 and 3), it was at once seen that something had passed through it from the north, leaving unmistakable traces. What first attracted attention was the smoothing of the rocks at *d* on the principal hill, and on the opposite side of the gorge at *eee* (see figs. 2 and 3 in Plate II.).

On the west-side of the gorge, the number of places ground down and smoothed were more numerous, one reason for which might be that the rocks appeared less hard than on the opposite side. On that side, there were some isolated patches of rock, which were well smoothed, because they had apparently encountered the full force of the agent which had passed through the gorge ; but there were other patches, as at *f*, which were quite rough, because apparently under the shelter of others.

The ground in the gorge rises pretty steeply from the north, viz., about 100 feet to its summit-level at B.

On four or five masses of rock on the west side of the gorge, and at about its narrowest part, were some most remarkable striæ on the smoothed rock surfaces. Mr Miller measured several of the longest, and found them to be 12 or 13 feet in length. They almost all sloped up towards the south, and were several feet above the bottom of the gorge. The angles of slope were measured by a clinometer. The average was 20° to 25° , but one was found with an inclination up south of 43° . In two cases it was distinctly seen, that the ruts were deepest and widest at their north ends, thus  Mr Miller found the rut, 13 feet long, was at its north end $1\frac{1}{4}$ inch wide, and $\frac{3}{8}$ ths deep; another was 2 inches wide at its north end. These tapered to a point at their south ends. The graving tool, which may have been sharp enough to cut deeply at first, becoming blunt as it was pressed upon the rock, had left a smaller and fainter striation as it passed along.

These marks seemed to make it quite clear that some powerful current had passed through the gorge, carrying fragments of rock

and stones, and squeezing them up over the summit level. In no other way, would it be easy—indeed possible to account for the smoothed surfaces at the sides of the gorge, and especially the striations, sloping upwards, and cut most deeply at their north ends.

There were no boulders in the gorge itself ; but on going to the summit level, and looking south upon the moors and hill slopes beyond, boulders were observed not far off, which may have come through the gorge, and been carried some distance.

There was no time that day for further research. But Mr Miller kindly undertook, at some future period, to visit those parts to the south of the Barone Hill, and report on any boulders seen by him.

The result of his survey will be seen in the last part of the notes sent by him, already given. It confirms the supposition that boulders were carried through the gorge, and were strowed over the hills to the south.

On returning to Rothesay by a route to the north of the principal hill, several small gneiss boulders were observed on a bit of flat land about 250 feet above sea-level. There also a portion of rock was discovered, consisting of strata nearly vertical, and ground down so as to form a flat surface. The edges of the strata were all abraded and smoothed in such a way as to show a passage over them of some hard and heavy body from the north.

ISLAND OF COLONSAY.

1. *Notes by Mr William Stevenson, 12 Meadowfield Place, Edinburgh.*

(1.) The rocks of the island generally are of a slaty nature, in some places curiously bent or twisted.

There are also places where granite rocks occur, as at and near the small boat harbour of Scalaseng, on the east side of the island.

The rocks inland from the harbour are in a sort of glen, through which a road passes. The granite rocks are seen there.

The walls of the harbour are built of this granite rock. It is of a grey colour ; but being somewhat soft in texture, it was faced with a yellow-coloured granite brought from Mull in ships.

(2.) On the west side of the island is Port Mor. It is only a

bay. Its shores are thickly strewn with boulders of all sizes, up to several tons in weight. They are mostly covered with sea-weed.

I was informed by Mr Donald M'Neill, a very intelligent farmer, long resident on the island, that many of the boulders in that bay resemble yellow Mull granite.

Mr M'Neill pointed out to me several boulders on his farm of Lower Kilchattan, which have distinctive names, some of them weighing from 2 to 3 tons.

He also spoke of a large boulder on the west shore, about a mile to the south of Port Mor, between Dun Gallon and Ardsinnish, called Fingal's Putting-Stone.

He mentioned that at Kiloran, on the north-west part of the island, there is a sandy bay which leads to another bay called Port Shipness, where there are many boulders.

Some large boulders are said to lie on the small islands to the east of Oronsay Island, where the old cathedral stands.

On several ridges of Colonsay, sloping towards the west, boulders occur, as at Mullbuie and Schoolhouse Brae. Those on Mullbuie are about a ton in weight.

All the hill tops are smoothed. On *Carnan-re-Erium*, the highest hill in Oronsay, there are said to be tracings of ice-markings; but I had not time to search for them.

In different parts of the coast there are shingle beaches composed of well-rounded, whitish coloured hard stones, about the size of a man's head, and under. Ships come sometimes to take away these stones, to be used for paving-stones.

2. Notes by Mr Donald M'Neill, Lower Kilchattan, Colonsay.

(1.) At the north-east of the island, on the farm of Balnahard, there are granite rocks.

At Sgalasaig there is granite rock on the shore and not far inland.

The granite rocks in Colonsay are everywhere of a dark grey colour.

(2.) The yellow granite used for building the harbour at Sgalasaig was brought from Mull by ships—a distance of about 12 or 13 miles.

(3.) There are boulders in various parts of Colonsay.

Those which are granite are (in my opinion) foreign to the island, being of a lighter colour than the rocks of the island. By some unknown means, they have been brought to where they now lie.

(4.) There are boulders of granite, whinstone, and quartz. Those of granite are generally on hill tops.

Those which I mostly noticed, are lying on hill tops and slopes of hills. There are also a number along the shore, on the west side of the island.

(5.) The boulders like paving-stones, are mostly on the north and west sides of the island, along the shore.

They are all rounded, and of an oblong shape generally, from the size of fine gravel, till some would rank amongst boulders. The highest bank of these heaps of paving-stones above the sea shore that I know, will be some 80 feet.

The Colonsay shingle beaches are the same as Jura's for nature of the stone ; but I believe Jura's are longer in extent, but not any higher above sea-level.

(6.) The Putting-Stone of the Fingalians lies on the sea side of Ardsinnish. It is one of the largest boulders in Colonsay. I believe it is whinstone, and weighs some 4 tons at least. It is round in shape. Tradition says the Fingalians used to throw it across the bay from where it lies to Dungallon on the opposite side.

The boulders that I am mostly acquainted with, are on hills sloping towards the south.

Boulders are lying on Colonsay's highest hills. I don't know how high above sea-level they are.

The foregoing notes, though supplied by gentlemen, neither of whom has geological knowledge or experience, appear to me exceedingly valuable. They show that on Colonsay there are boulders well deserving of study, in order to ascertain from what quarter they have come. From the fact stated by Mr Stevenson, that many boulders lie on hill sides sloping towards the west, it is probable that the boulders came from some westerly point,—perhaps from the Island of Mull. But by an examination of the manner in which the boulders have been set down or placed, by

the agent which brought them, a conclusion on this point may be arrived at.

The thanks of the Committee are due to Mr Stevenson and Mr McNeill for their attention to the Convener's application to them in this matter.

LINLITHGOWSHIRE.

1. Two years ago, the Convener, having been kindly invited by Mr James Melvin, tenant of Bonnington Farm, to examine some boulders near his farm, went there under his guidance.

On *Pumpherston* Estate there is a bit of ground higher than any adjoining district, on which there is still a considerable number of boulders, though formerly there were more. The height of the spot is about 430 feet above the sea.

The largest goes by the name of the "*Ballengeich Boulder*." It is in girth 10 or 12 feet. The spot on which it lies is about 3 feet above the adjoining ground. The boulder, though at one time an entire mass, now consists of eight fragments. How it has been broken, and when, is of course matter only of conjecture. It seems due to some natural cause. It may have been caused by atmospheric action, or by falling from a height.

It is evidently an erratic,—being a coarse dolerite—of which there are no rocks known, nearer than the Bathgate hills to the N.W.

The eight fragments combined would produce a mass of from 50 to 60 tons.

Mr MacLagan, M.P., the proprietor of the land, having been so obliging as to send a labourer with a pick and spade, a pit was dug in two places adjoining the boulder to ascertain the nature of the substance on which it was lying. Boulder clay of a blueish yellow colour was below. The block had sunk into it about a foot.

2. Not far from this boulder there is another, about a quarter of a ton in weight, of quartzite with crystals of green mica, most probably from the Highlands.

The other boulders were smaller in size, and of ordinary trap,—a rock abounding in many of the adjoining hills.

3. On the farm of *Bonnington*, there is a boulder known as the "*Witch's Stone*," about the same size as that on *Pumpherston*, at a height of about 431 feet above the sea.

It is on *Tornain Hill*, and on a slope, which faces W.N.W.

It is a dolerite, though not so coarse as that on Pumpherston.

Mr Melvin had an excavation made under the boulder, and ascertained that it rested partially on the trap rock of the hill; this rock, however, being different in composition from that of the boulder. The nearest rock of the same kind, known to Mr Melvin, he stated to be in the Bathgate hills, situated about 5 miles to W.N.W.

There is a valley between these hills and Tornain Hill, across which the boulder must have been transported.

This boulder, like that at Ballengeich, has been broken, and consists of six fragments. The principal mass lies to the west of the fragments, as if they had been broken off by some force from the westward; or they may have been broken off by concussion if the original mass fell from a height.

The fragments have certainly not come off at any recent period. Judging by their surfaces they look quite as ancient as the principal mass.

The principal mass is well rounded on all its sides, suggesting much rough treatment ere it reached its site.

Some interest attaches to the boulder on account of a set of "cup markings" on it, of which an account is given by Mr Smith in a late volume of the "Transactions of the Scotch Society of Antiquaries."

It is right to add that if a line be drawn from Tornain Hill to the Bathgate hills, it passes close to the site of the Ballengeich boulder.

4. Mr Melvin mentioned to the Convener that, on the S.E. side of this Tornain Hill, there was once a dolerite boulder (which he had seen) measuring $21 \times 5 \times 4$ feet, lying with its longer axis E. and W., and at a height of about 300 feet above the sea.

If it came from the Bathgate hills (which was probable), it could, in his opinion, have come only by floating ice, through the valley between Tornain and the Crow hills, *i.e.*, from the westward.

5. Mr Melvin further informed the Convener, that in the channel of the River Almond, below Kirkliston, there is a boulder of Old Red Sandstone conglomerate,—the nearest parent rock of which was probably the well-known belt of conglomerate crossing

Scotland in a N.E. direction from Dumbarton. This conglomerate boulder, $5\frac{1}{2} \times 4\frac{1}{2} \times 4$ feet, had its corners well rounded. The nearest point to the parent rock *in situ*, would be at or near Callander, a distance of about 40 miles, in a direction about N.W., with several ranges of hills and valleys intervening.

6. Mr Melvin, at Ratho Railway Station, drew the Convener's attention to the greenstone rocks there, how they were well rounded and smoothed on their sides facing the W. whilst on their sides facing the E. they were rough.

He also pointed out how, on several of those smoothed surfaces, there were numerous striæ and ruts running in a direction W.N.W. and E.S.E. (magnetic).

Portions of these smoothed and striated rocks were covered by boulder clay or till, containing many small boulders and hard pebbles, which, by passing over and pressed down on the rocks, might have produced both effects.

A number of large trap boulders were lying about. The largest examined, weighing between 2 and 3 tons, had horizontal striæ on its side, which faced N.N.W. These striæ might have been formed by a force coming in a direction from W.N.W. and striking obliquely on that side of the boulder.

This locality is at a height of from 180 to 190 feet above the sea.

*NOTES BY PROFESSOR FORSTER HEDDLE,
OF ST ANDREWS UNIVERSITY.*

LOWLANDS.

In April 1880, whilst there was still so much snow on the Highland hills as to render explorations on them impossible, the Professor went to Dumfriesshire, having received notice of two boulders among the Wanlockhead hills.

(1.) The first he examined, called "The Crooked Stone," lies in a field on the right bank of the Clyde, about 3 miles above Elvanfoot Station. The stone protrudes above the surface about 5 feet. Its width is nearly 5 feet; its thickness about $1\frac{1}{2}$ feet.

It is on a knoll projecting somewhat above the adjacent river-terrace.

The rocks about *in situ*, are Greywacke. The boulder is also Greywacke, but much more gritty than any of these rocks in its neighbourhood.

In walking some distance up the valley, at the mouth of which the boulder lies, gritty rock, similar to that of the boulder, was met with on the slopes of Dunlaw Hill.

(2.) The other boulder lies within a field on the north side of Cranwich Water, about half way between the farm of Crossbank and Spango Bridge.

This stone protrudes about 4 feet above the ground,—and is nearly rectangular, the breadth of the sides being each about $2\frac{1}{2}$ feet.

It is a Dolerite, formed of platey augites in large crystals, with very little felspar. It has an unusually rough surface. It differs from any rocks in the neighbourhood, but resembles the rock of three Dolerite veins (or dykes?) which cross the country some miles to the north.

(3.) To try and discover the parent rocks of these boulders, a walk was taken along the central ridge of the Lowthers, as well as along several of the spurs and valleys stretching on the one hand to the Clyde, and on the other to the Nith, but without result.

To save trouble to future explorers, it may be mentioned that the following hills were ascended, viz., Lowther Hill, Green Lowther, Dungrain Law, Dunlaw, Hawk Wood, Broad Law, Hunt Law, Slough Hill, Stoor Hill, Glen Gober Hill, Low Mill Knowe, Clock-hill Hill, The Dods.

HIGHLANDS.

For the reason just assigned, the Professor notes in detail the various mountains visited, though no boulders were found on them. He observes, that had this practice been followed by previous geological surveyors, he would probably have been saved many a toilsome climb during the last two years.

But he states an additional reason for indicating the mountains where no boulders were discovered.

From last year's Report it will be seen, that he had observed, in at least two districts of Argyleshire, distinct "*streams of boulders*," while the districts adjoining these streams contained none.

The fact of there being two such streams, suggested the probability of there being others ; so, as both of these streams indicated a direction about east and west, he resolved to cross the country in a north and south direction elsewhere, at the same time following, as much as possible, the ridges of the hills lying that way, and climbing to the summits, for the sake of having an extensive view. Being accompanied in this expedition by two or three friends, each provided with a binocular, it was not likely that boulders of any size, visible within half a mile of the route followed, would be missed.

Professor Heddle carried with him an Ordnance map with contour lines, which at once indicated the heights of the hill ranges, and on these he has drawn, with a thick red line, the exact route taken. This map he has sent to the Convener. To him it has been of much service by enabling him to follow the Professor's notes.

But, before specifying the names of the hills visited, and the results, it is not unimportant to notice some remarks by the Professor of a general nature bearing on the best way of boulder hunting.

He states that former explorations had impressed upon him the advantages of making a search chiefly along hill ridges, and of scaling hills to their summit. In the *first* place, a more extended range of observation is obtained, and in the *second* place there is more probability of finding the boulders in their original positions.

If boulder hunting is carried on in glens or valleys, as has hitherto usually been the case, the range of observation is exceedingly limited ;—whereas, from a hill top, a panorama of a wide range of country may be obtained, which, besides showing boulders, makes the gradients of the country more intelligible, and indicates where there may have been passages for ice, whether land or sea ice.

Another advantage is, that if boulders are met with on hill tops or hill ridges, it is almost certain that they occupy the position in which they were originally placed by the agent, whatever it was, which brought them. But boulders in a valley, or on the sides of a valley, may have rolled down from a higher level, and thus afford far fewer data for safe reasoning.

Professor Heddle observes that there are ranges of hills of con-

siderable elevation, more or less continuous, which stretch northward, commencing near Rowardennan, to the south of Ben Lomond, and reaching to the neighbourhood of the Dochart and Loch Tulla, where the stream of boulders was first recognised by him in the previous year.

1. This accordingly was the general line of route he decided to take, and the following is a diary of his explorations.

First Day.—Rowardennan to Inversnaid, by *Ben Lomond* (3192 feet).

Near Rowardennan, much appearance of glaciation along banks sloping to the loch, showing a southerly movement.

A dyke of Diorite strikes eastward above Rowardennan to a height of about 450 feet. A few small blocks from this dyke lie a short distance from it on its south side;—but there are none on the north side.

At the foot of the north slope of *Ben Lomond*, a very unusual and characteristic Greywacke rock *in situ* was noticed. It contains nodules of milk-white quartz larger than almonds. It will be referred to when an excursion along the Ochils comes to be mentioned.

No noticeable boulders were found.

Second Day.—Crossed Loch Lomond, and went along the whole ridge of *Ben Vorlich*, and over its two summits (3092 and 3055 feet) on to Inverarnan. *No boulders were seen.*

Third Day.—Ferried the River Arnan, and went along the terribly rough ridge of *Ben-a-Chabair* (3054 feet); then down into the col between it and *Ben-a-Chastle*; then up to the top of *Ben-a-Chastle*, then down along its ridge (where saw the *Brocken*, for the second time in Scotland) to Crianlarich. *No boulders.*

Fourth Day.—Went over *Crag Loisgte* (2750 feet), *Ben Challum* (3354 feet), down to Strath Lochy; then over *Stron-nan-Eim* (2747 feet) and *Creag Mhor* (3387 feet); then, down into the col between its second top and *Cam Chreag* (2887 feet); next, over the latter into *Glen Choilleun*, then, over *Beinn Odhar* (2848 feet) and down its ridge, back to Crianlarich. *No boulders seen.*

But in the col between the second top (name not given in inch map) of *Creag Mhor* and *Cair Chreag*, some interesting and puzzling appearances attracted attention, which the Professor says he had noticed in other parts of Scotland.

At the very head of the col (2480 feet), just where it folds over to the watershed, where streams rise to flow in opposite directions, "there are numerous heaps of gravel similar to what are known among the Swiss glaciers as '*dirt cones*.' These were higher and larger in the sides of the trench, than in its centre. They continue but a short distance down the valley on each side, diminishing in size towards the lower levels."

If "*dirt cones*" (as is generally alleged) be formed by running water on the surface of ice, carrying stones over the edges of the crevasses and depositing them at the bottom, may it not be inferred that there was a mass of ice here which, at the col, broke into two divisions, forming a glacier for each valley?

(The Professor remarks, that this was the second hardest walk during one day which he ever took, the distance travelled being 26 miles, and the amount of ascent being 7900 feet.)

Fifth Day.—Returned to re-examine the col, going by the valley between *Ben Chaluim* and *Ben-nan-Marsen* to top of *Creag Mhor's* second top, then over the col to *Cram Creag*, and back by *Glen-a-Clachain*.

No boulders seen.

Sixth Day.—From Tyndrum over *Ben Doreann* (2523 feet) to Inverarnan. *No boulders* were seen, except some mentioned in last year's Notes (these apparently omitted to be noticed in last year's Report), near the bridge over the Orchy.

Seventh Day.—Examined the sides of *Ben More* (3843 feet), *Stob Luib*, and the trench of the Dochart. Found the highest glacial markings to be upon *Stob Luib* at a height of 750 feet above *Luib Railway Station*.

From the material of the till, and the closed nature of the country, the Professor concluded all to be due to a local glacier rising in *Ben Laoch*, and largely fed from *Ban-nan-Imareau* (2769 feet) and other hills north of the Dochart; the glacial striæ on *Stob Luib* pointing more to these hills than directly up the glen. *Ben Laoch* bears W.N.W.

Eighth Day.—Went over *Ben More*, *Am Binnean* (3827 feet), *Stob Choire an Lochan* (3497 feet), *Am Mam* (2500 feet), *Meal Monachyle* (2122 feet), down the *Braes of Balquhiddy* to Loch Earnhead. No boulders and no glaciation over the great

col between *Ben More* and *Am Runican* (2800 feet) were seen.

Ninth Day.—Went again over *Ben Vorlich*, then over *Sturch a Chroin Meal Odhar*, to Callendar. *No boulders.*

Tenth Day.—From Callendar over *Ben Ledi* (2882 feet); a hill ridge to *Ben Vane*, and down to *Strathgrye*. *No boulders*, except some of gneiss near Callendar. (On three of the following days Professor Heddle was alone, on the others he was accompanied by a party of never smaller than four. The sides and ridges of the hills were swept by binoculars.)

Professor Heddle's notes next mention his return to Arrochar, and on the *first* day ascending the *Cobler* (2400 feet), making the circle of its summit, and descending to the col between *Ben Narnan* and *Beinn Ime* (3318 feet), and returning by the valley between *Ben Narnan* and the *Cobler*. He observed glaciation (ill-defined) passing north-eastward. There were a few rounded blocks of Syenite lying on the col, which seemed to have been moved in a north-easterly direction, from veins of that rock in the col.

On the following day he ascended *Ben Arnan*, through and by the sides of what he terms a "*Cradle Cup*," to its summit, and then down to the col between it and *Ben Ime*, to the col between it and the north hill (name unknown), down by *Choiregrogain* and back by *Glen Loin*. Boulders of the same Syenite were seen on several parts of *Choiregrogain*. Several veins or dykes of this Syenite were found, especially a very large one protruding from the north shoulder of *Crois* (2785 feet). Assuming that the boulders came from these dykes, they had by some agency been transported eastward.

The "*Cradle Cup*," lying between *Crois* and *Ben Arnan*, is described as "an elevated and confined little valley," with a rocky dam, which if *nevê* was formed there, might have retained it long enough to allow of it being converted into ice, supposing the climate to have been supposed suitable. Not even in the contracted portion of valleys, is there so marked an amount of grinding, grooving, and polishing seen, as was seen upon the inner side of the rock dam of this "*Cradle Cup*." These evidences of ice action, at an elevation of only 1500 feet above the sea, are all the more remarkable, on account of the total absence of glaciation

throughout the whole sweep of *Choiregrogain* from its extreme altitude of 1700 feet down to the level of Loch Lomond.

The manner in which this little *Choire Sugach* is shut in from the west—*first*, by the spur which connects *Ben Arnan* with *Crois*; and *secondly*, by the towering bulk of *Ime* to the back of this; and *thirdly*, the palpable shedding of its ice to the eastward, out of a hollow surrounded with craggy and rough-edged rocks, and in a district which no where else shows glacial action, is unfavourable to the supposition that the ice which had been grinding the rocks had come either from any floating sheet from the west, or from any enveloping mantle from the east. The parts here seem to show that though elsewhere there may be examples of either or both of these agencies, there is evidence that the temperature of the country was at one period such that glaciers, however small, were generated and cradled among its hills.

From *Arrochar* Professor Heddle walked across the range of hills towards *Loch Gailhead*; one day was spent in visiting *Loch Restil* and *Ben Lochan* (2955 feet). On the following day he went up *Corry Corran*; then, over the shoulders of *Beinn Lochain* (2304 feet); then, into the trough of *Curra Lochain*; over the ridge and top of *Beinn Bheula* (2557 feet); over the north shoulder of *Cnoc na Trieriche*, down to *Lochan nan Cnaimh*, over *Crauch nan Miseag* (1989 feet) and back to *Loch Gailhead* by the shore. No boulders, moraines, or traces of glaciation were seen during these two days.

Professor Heddle, on a review of the whole of the foregoing explorations, states that the South-Western Highlands appeared to be singularly barren of boulders at high elevations, and that the only traces of ice afforded evidence of glaciers of small size, formed in some of the valleys and hollows among the higher hills.

He thereafter decided to return to the more northern district of the Highlands, where in the previous summer he had met with boulders of large size, not only perched upon ridges, but forming streams, stretching for miles continuously.

As one of these streams had been found on the Moor of Rannoch, and extended eastward to and beyond Loch Tulla, he went to Fortingall, that he might from that point follow the chain of hills which block more or less the moor at its eastern end.

The course lay over *Ben Dearg* (2000 feet), *Creag Mhor* (3000 feet), an unnamed hill west of this (3240 feet), *Carn Mairg* (3419 feet), *Malharran Odhar* (2230 feet), *Geal Charn* (2595 feet), *Creag Mhor* (2250 feet).

Nothing was discovered on any of these hills till *Geal Charn* was reached. After the top of it was passed, and about 400 yards beyond it, at the height of 2498 feet, two boulders were found, about 100 yards from each other, and weighing each about 7 tons. This hill of *Geal Charn* with *Creag Mhor* to the north, forms a continuous ridge running nearly north and south, crossing therefore the great central trough, of which the Moor of Rannoch forms part, the general level of which moor is not more than from 900 to 1000 feet above the sea. If, as the explorations of the previous year showed, boulders had been dropped by some means from the west along Rannoch Moor in the form of a stream, none were likely to be found on any of the hills to the south of *Geal Charn*, as these hills were blocked by higher hills to the west, such as *Meall Garbh* (3048 feet) and *Meall Bnèar* (2291 feet). On examining the rock composing these two boulders, Professor Heddle was of opinion that it was the same as that of the boulders lying near Loch Tulla, and which he had tracked, from one hill to another, till a rock *in situ* the same in composition was found on the high hill called *Albanach*, about 12 miles to the west. The only difference which he could detect was, that the rock of the *Geal Charn* boulders was "somewhat of a coarser grain."

Conceiving that this hill of *Geal Charn*, by lying transversely across the trench, had caught some of the boulders, it occurred to Professor Heddle, that as the loftier mountain of Schehallion, situated about 3 miles to the east, was also in such a position, that it may have intercepted some of the *Albanach* boulders, he ascended it on the following day.

He had not much expectation of finding boulders on it, as it forms an elongated range in a nearly east and west direction. However, when he was about 140 feet from the summit (which is 3430 feet above the sea), he did find at its west end, a boulder of *Albannach* granite, of about three-quarters of a ton in weight.

Professor Heddle states that he looked about for more granite blocks, but did not fall in with any. The sides near the top,

especially on the north side, he says, are covered by "loose blocks of the porcelain porphyry of which the hill is formed."

The Convener can on this point supply information obtained by himself some years ago, on the occasion of his ascent of Schehallion. He gives the following extract from his geological diary:—

"1872, August 27.—Went up Schehallion, in company with Principal Shairp of St Andrews and Professor Blackie. We began ascent at 1^h 50^a, and reached summit at 5^h 10^a.

"We went up by a ridge of the mountain running east and west. The height of hill I made by aneroid, 3450 feet. I believe Professor Nicol made it 3561.*

"For the first 1000 or 1500 feet, from where we began our ascent (at Braes of Forss) on east side, beds of sand and gravel were observed. Near the top, there were quantities of small pebbles, apparently fragments of the hill rock, which is a sort of hard sandstone, somewhat like quartzite. Near top, *observed a few small granite boulders.*

"The upper part of the hill, especially on side facing W.N. by W. (magnetic), was comparatively smooth, but saw no striations. On that side, however, the angles were more rounded than on any other side.

"On descending, we did not return along the ridge or back-bone by which we had ascended. We slanted down in a S.E. direction. On the way, I noticed *various granite boulders*, but none exceeding a ton in weight. I chipped some, and found them to be all a fine-grained gray granite. These were most numerous, at a height of from 2000 to 3000 feet above the sea.

"Observed also in our descent, that there were smoothed rocks, and chiefly at a height of about 2500 feet. I was struck with the fact, that I saw no smoothings *above* that height.

"Observed in the banks of the burns flowing down the south side of Schehallion, high cliffs of boulder clay, at a height of about 1200 feet above the sea.

"On showing my chips of the boulders to Principal Shairp, and asking if he had ever seen elsewhere rocks of a similar composition, he said he had been at Loch Sunart last year, and had noticed granite rocks there very similar to that of the boulders."

* By Ordnance Surveyors it is made 3547 feet.

The contour lines on the ordnance map indicate that the longer axis of Schehallion runs about W.N.W. and E.S.E. It has a large flank facing the W.S.W., which could, therefore, readily intercept any boulders brought from any point between S. and W.N.W.

Since the foregoing paragraphs were written, I have found further proof of there being granite boulders on Schehallion, in the following extract from a paper by the late Robert Chambers in the "Edinburgh New Phil. Journal for 1855" (vol. i. p. 101).

"Schehallion is composed of quartz rock. It is abrupt to the west, and tails away to the east. I found surfaces at several places bearing that peculiar streaking which I had remarked as a glacial phenomenon peculiar to quartz rock, on the mountain of Queenaig in Assynt. At about the height of 2200 feet above the sea, there is a fine group of examples. There is another similarly striated or streaked surface, a few hundred feet below the summit of the hill. The *direction of the striation* in both instances is W. 30° N. About 800 feet below the summit, I found *a block of granite*; and in several other places there are blocks of other rocks, likewise different from those of which the hill consists. From all I have seen, I entertain no doubt that Schehallion owes its form to a glacial agent, which has engulfed the whole range."

These observations by Dr Chambers confirm Professor Heddle's statements on two points:—*first*, as regards the existence of granite boulders on Schehallion; *second*, as regards the direction of the stream which brought them; for there can be little doubt that the transport of boulders and the striation of rocks on such an isolated mountain as Schehallion can be well accounted for by the same agency.

The result of these explorations in the Black Mount district has, therefore, been to confirm the correctness of the conclusions come to in the previous year, that boulders had been strewed over the district in a sort of *trainée* from Albannach Hill in an easterly direction, and that portions of the stream had reached Schehallion. Some of these boulders were in last year's Report stated to have been found at a height of 2530 feet above the sea. Last year's explorations showed them in positions 2498 feet (on Geal Charn) and 3407 feet (on Schehallion) above the sea.

Albannach Hill reaches to a height of 3425 feet above the sea.

Some hesitation may be felt in assuming that the boulder on Schehallion, being only 18 feet below the highest summit of Albannach, could have come from Albannach; but it is quite possible that Albannach Hill may, since the boulder epoch, have been lowered by denudation.

Professor Heddle adds, that having heard that other observers had found boulders on Schehallion, and which were supposed to have come from the Ben Alder district, he thinks it right to mention that there is in fact no granite in the hills of that district, except at one locality, where Prince Charles's Cave is situated, at which place the granite is composed of crystals an inch or more in size, by which it is quite distinguishable from the boulder found on Schehallion, and from the Albannach granite.

2. Another district examined last year by Professor Heddle, was both banks of the Linnhe Loch to the east of Fort William.

It will be seen from last year's Report, that at two places there were appearances for which he could not account, except on the supposition that some agent had brought boulders across the Linnhe Loch, from the district of Glen Tarbert, to the districts at the head of Glen Crerar and Glen Etive.

In order to seek for symptoms of glaciation in the Glen Tarbert district, Professor Heddle last year crossed by the Connal Ferry.

That glen, and several hills and valleys adjoining it, were examined with little success. Boulder clay only was found, viz., in Glen Tarbert itself.

At length a valley called *Coir Syveamhael*, running in a N.W. and S.E. direction, was found "tremendously glaciated" between the altitudes of 950 feet and 1550 feet.

Marks of glaciation were also strong between *Meall Challium* and *Meal-a-Chairean Zuachraid*. These marks showed movements not only over the col (1680 feet) but for a certain distance up the north slopes of Meal Challium, the rocks of which had been powerfully acted on. The course of the ice, judging from the smoothings of these rocks, seemed to have been from W.N.W.

The glaciation extends down into the valley called *Coire Meall Challium*, the sides of which are so marked, down to a level of about 950 feet.

No boulders were found on these hills or in the valleys.

From these glaciated hills a view across the Linnhe Loch was obtained; and in particular, looking along the groovings of the rocks on the sides of *Coire Maell Chailium*, the eye catches a sight of the trench of the *River Durer*, and hits upon "the very spot in the small *col* in the spur of *Fraochaidh*, where, at almost the same altitude, glacial *strivæ* were observed in 1879."—(See p. 42 of last year's Report.)

Another set of hills visited on the north side of the Linnhe Loch are those embracing *Glen Conar*. Having followed up the glen for 3 miles without finding boulders or marks of glaciation, Professor Heddle states that he struck off by hills marked on the ordnance map, *Sgur an Lubhair*, *Stob Coire Riach* and *Stob Choire a Chearchaill*. On the last-mentioned hill he found so remarkable a *trainée* of boulders that it at first occurred to him they might possibly have been derived from a natural dyke or vein which had disintegrated. He searched carefully for such, but could see no traces of any. The boulders—for such he now considered them to be—lay on and along a ridge of the hill for nearly a mile, at heights varying from 2400 to 1800 feet, below which last level none were found. The directions of the *trainée* was N.W. and S.E. The boulders were generally not larger in size than a cubic yard, and consisted mostly of a peculiar syenite with some of the felspar crystals of a red colour, and with hornblende of a lively green colour. He counted nineteen boulders of that kind. There were also other boulders interspersed, of ordinary syenite, gneiss, and trap.

As it appeared to him that the ice which brought these boulders had crossed the Linnhe Loch, Professor Heddle next visited several hills on the opposite or south side of the Loch, in hopes of discovering boulders of the same peculiar syenite. One of the many hills visited was *Bein Bhan*, reaching to a height of 1500 feet. The rocks in this hill are of clay slate, and at its summit on the east side, there is quartzite with embedded crystals of hornblende. Another hill, not far off, is *Beinn na Gucaig*, reaching to a height of 2017 feet, composed of quartzite overlying clay slate.

On both of these hills, boulders of the peculiar syenite seen on the *Stob a Chearchaill* ridge were found, up to their respective summits.

On the *Bein Bhan* hill a ridge runs up from the north-east towards its summit, on which ridge one of the boulders was found

in so peculiar a position, that a sketch of it was taken, the shading being filled in by Mr Colin Philip (an artist) who accompanied Professor Heddle. (See fig. on Plate III.)

The boulder occupied a sort of notch in the rocks of the ledge, as if brought from a northern point. The boulder was lying on some fragments which had evidently been broken off the bottom part of the boulder. The question arose, What had caused these to break off? Atmospheric action did not seem the agent. The surfaces of the fragments where rent, were somewhat conchoidal in shape, and indicated rupture by violence. The most probable explanation which suggested itself was, that it had tumbled off the raft which carried it, and, being of great weight, had broken by concussion against the rock of the hill.

The Convener who has made the foregoing extracts from Professor Heddle's notes, thinks it only due to him to mention that these extracts give no idea of the enormous amount of labour which the Professor has undergone in his boulder researches. During the summer and autumn of 1880, he must have walked several hundred miles, over districts many of which are not accessible to ordinary pedestrians. This is shown by the tracks of his surveys laid down by him on the ordnance maps, and by the names given in his notes of the hills and valleys visited. A great part of these expeditions were unsuccessful and disappointing; but he has specified them in full detail, in case the committee might deem it useful to record in their Report the districts visited, for the information of future observers.

The Committee, at a meeting held on 24th June 1881 for the adjustment of the Report, where Professor Heddle's notes were shown, and some portions read to the Committee, were of opinion that they had been too much abbreviated by the Convener; and they requested him, on revising the proofs of the Report, to give more copious extracts, which accordingly has been done.

NOTE BY RALPH RICHARDSON, Esq.

Loch Skene.—A letter from Mr Ralph Richardson to the Convener, dated 11th March 1881, gives an interesting account of boulders, at a considerable height, near Moffat:—

“*R.S.E. Boulder Committee*.”

“I beg, as desired, to report to you, as Convener, that when visiting Loch Skene, Dumfriesshire, last August, I observed some large boulders, about 200 feet above the Loch, in the valley traversed by the Midlaw Burn, between the Mid-Craig and White Coomb hills. These boulders are situated about 1900 feet above the sea-level, and appear generally to belong to the local Silurian rocks. I measured one, and found it to be 30 feet in circumference, 9 feet in height, and 9 feet in breadth. There were others of similar size. The valley in question is dotted with what seem to be moraine heaps, and similar mounds are found damming back the waters of Loch Skene. Scott in ‘Marmion’ refers to these ‘rude barriers.’

“An admirable description of the Geology of this district is given in a paper by Dr John Young in the ‘Quarterly Journal of the Geological Society of London,’ vol. xx. p. 452 (1864).

“The boulders to which I have referred are evidently not far travelled rocks, but they are interesting as ‘perched blocks’ occurring at an altitude of 1900 feet. I infer, from the adjacent moraine evidence, that they were transported by a local glacier, which had its *névé* or gathering-ground at the head of the Midlaw valley; which descended to Moffatdale along the present drainage-line, viz., the courses of the Midlaw and Tail Burns; and the northern lateral moraines of which formed barriers to the drainage from the north, resulting in the formation of a sheet of water now known as Loch Skene.”

EXTRACTS FROM PAPERS BY MR JAMIESON.

ABERDEENSHIRE AND PERTHSHIRE.

As it is an object of the Committee to collect information about boulders from all reliable sources, the following notices are taken from papers by Thomas F. Jamieson, Esq., published some years ago in the Proceedings of the London Geological Society:—

(1.) In his paper “On the Pleistocene Deposits of Aberdeenshire” (“Quart. Journ.” for 1858, p. 512), Mr Jamieson describes the “*mounds and ridges of coarse ferruginous shingle and gravel, all water rolled,*” situated to the north of the town of Aberdeen, near the seashore. “The fields abound with *large boulders*, mostly of syenitic greenstone and other varieties of trap, similar in quality to rock *in situ*, a few miles to the west, near the Menie coastguard station; I found these large boulders of trap, granite, and gneiss, *resting on the top and surface of the gravel ridges*, some of them measuring 6 feet in length, and more or less rounded in form. I traced them also among the low hillocks of blown sand, occurring sometimes singly, sometimes in clusters, and of various sizes up to 11 or 12 feet in length. In a field on the farm of Drums, a gigantic granite boulder occurs, known as ‘the grey stone.’ I found it to measure 54 feet in circumference, with a height of about 7 feet above the ground. It has no sharp angles, and most of its exterior is rounded. Another immense block, also apparently a transported mass, is seen—78 feet in circumference, and projecting 6 feet out of the ground—a coarse-grained greenstone.

“These ridges consist of highly rolled fragments of rock of all sizes, from coarse gravel up to boulders 2 feet in diameter. On the top of one of these gravel ridges, a little to the north of Drums, I found a boulder of coarse crystalline rock measuring 8×5 feet; no sharp angles occur on its surface; a layer of red clay, about 9 inches thick, overlies the gravel at this spot. This boulder rested immediately upon the gravel, but the clay encircled its base; another large boulder of greenstone lay beside it.

“These are instances of large transported boulders sitting on the top of abrupt ridges of water-worn shingle.”

(2.) In his paper "On the Drift and Rolled Gravel of the North of Scotland" ("Quart. Journ." for 1860, p. 365), Mr Jamieson, referring to "a great ridge of *mica-slate* stretching in an east and west direction, between Loch Tummel and the valley of the Tay," says, that "all along the northern slope of this ridge, from Meal Uaine at one extremity, westward for 10 miles to Hioch Vore at the other, I remarked many boulders of *granite* and *porphyry*, at heights exceeding 2000 feet, the highest being one of granite, at an elevation of 2390 feet.

"Now I examined the greater part of that ridge, crossed it at several points, and walked along its crest for miles, but saw no indication anywhere of this granite or porphyry *in situ*. I think, therefore, they must have been carried to their present position from a considerable distance, and, knowing that such rocks occur in the high mountains situated to the *northward* (as, for instance, Glen Tilt), it is probable, that *there* lies the source from whence they have come.

"It is not at 2000 or even 2400 feet, that we cease to find such transported fragments. In the Braemar district I met with them much higher.

"A remarkable instance of this occurred on the hill of Morven, a few miles to the north of the village of Ballater. The average of four measurements makes the height of it 2953 feet above the sea, the highest value being 3048. It stands many miles apart from any hill of like elevation; in fact, there is none so high within 10 miles, and it greatly surpasses any eminence to the north and east between it and the sea. All the upper part of the mountain, so far as I could ascertain, is composed of one sort of rock, which seems to be a mixture of *greenish hornblende* and *white felspar*. No *gneiss*, *quartz-rock*, or *granite* came under my notice, although the last-mentioned rock occurs about its base. The late Professor Magillivray had, I find, examined the hill, and pronounced it to be hornblende rock. It was, therefore, with no small degree of wonder, that I remarked several rounded boulders of *granite*, together with some of *quartzose gneiss*, or *laminated quartz*, lying here and there on the western brow of the mountain, and I traced them up to the very summit—one or two, indeed, are built into the cairn that

marks the highest point. The largest of these fragments did not exceed 2 feet in diameter.*

"Again, there is a hill close to the village of Braemar, named Cairn-a-Drochet, reaching an elevation of 2700 feet. Seventy yards to the north of the cairn that marks the summit, there sits a *block* of coarse *red granite* 12 feet in length, while many boulders of the same kind are scattered all around. Now the upper part of this hill is chiefly composed of *quartzose gneiss*, intersected with dykes and masses of felspar porphyry, and although *granite* also occurs *in situ* a short way down the hill, yet it is of a different quality from this block, containing a much smaller proportion of quartz, while the felspar is of a paler tint, and, upon the whole, I think it likely that this block and many of the other boulders near it have been derived from the mountains to the north, the granite of which is identical in character. Whilst not meaning to press this too strongly, I would remark that the fragments of quartz, felspar, porphyry, and granite on the flat top of the hill are mingled in such a way as to indicate exposure to some shifting agency, as if they had been washed about together while under water.

"The only other instance of high-lying fragments, apparently transported from a distance, that I shall adduce, relates to the mountain called *Ben Uarn More* (3587 feet). It forms the culminating peak of the great ridge that divides the shires of Aberdeen and Perth, and is composed of *quartz rock*; no other rock occurred, as I clambered up the steep northern slope, but I observed here and there, as I went along, fragments of a peculiar kind of *porphyry* that I had not met with *in situ* lower down. These fragments continued to occur, though sparingly, high up on the shoulder of the mountain, but on the very top I looked some

* The Convener having sent to Mr Jamieson a proof of this part of the Report for his revision, returned it, with the following note:—"The Rev. J. G. Michie of Dinnet, accompanied by the Rev. Mr Davidson of Logie-Coldstone, paid a visit to Morven on the 12th October 1874, in order to make a special examination as to the occurrence of these boulders. Mr Michie wrote to me, that they saw some large blocks of *granite* at the base of the mountain, and small boulders of *granite* were likewise found sparingly all over the top of the hill, up to the very summit; but there was a considerable space about half way up, where there seemed to be an absence of these boulders. No granite rock was found *in situ* on Morven itself; the rock, so far as could be seen, being of the nature of hornblende schist."

time for them in vain. A cairn on the summit, apparently the work of the Ordnance surveyors, showed nought but quartz, the sharply angular *debris* of which strewed the protruding edges of the strata. Searching about among the quartz *debris*, I did, however, find on the very top of the hill a small lump or two of the same *porphyry*; and other fragments of it occurred as I descended the shoulder of the mountain."

(3.) In his paper "On the last Changes of Scotland" ("Quart. Journ. of Lond. Geol. Soc." for 1865, p. 165), Mr Jamieson states, that "the detached mountain of Scheshallion (Perthshire), 3500 feet high, is marked near the top as well as on its flanks, and this not by ice flowing down the sides of the hill itself, but by ice pressing over it from the north. On the top of another isolated hill, Morven, about 3000 feet high, situated a few miles to the north of Ballater (Aberdeenshire), I found *granite boulders* unlike the rock of the hill, and apparently derived from mountains to the west.

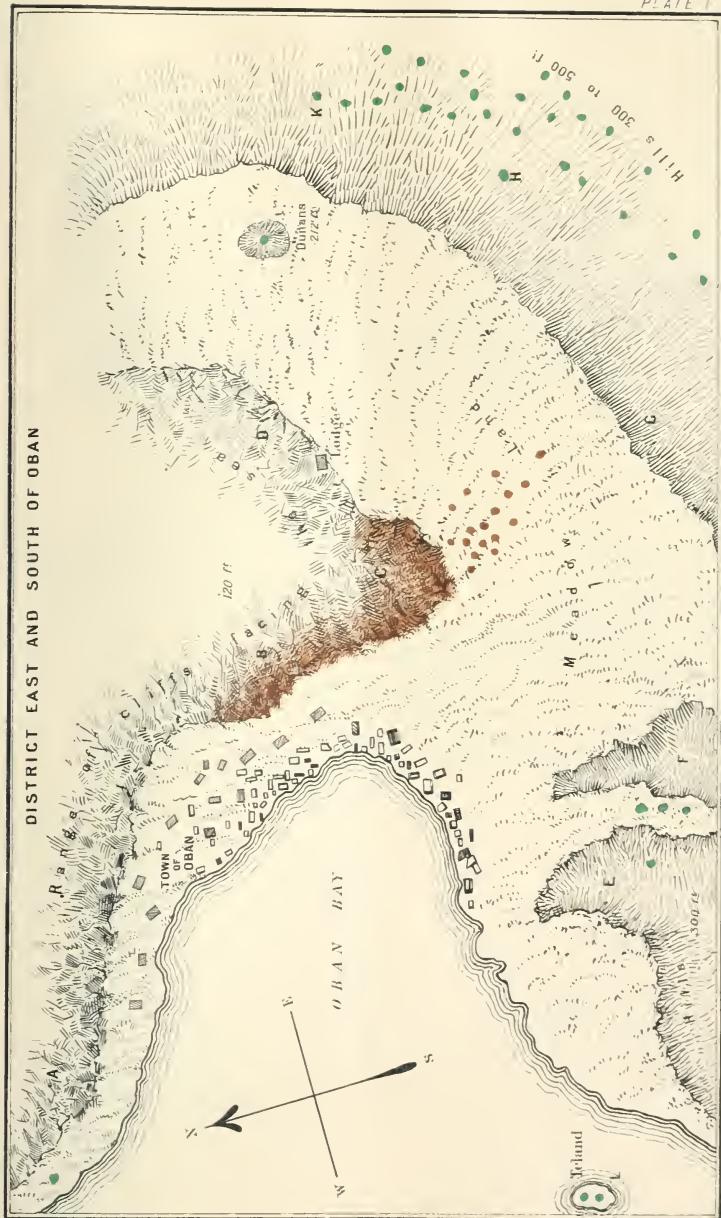
"Again, on the highest watersheds of the Ochils (a range of trap-hills stretching from Stirling towards Perth), at altitudes of about 2000 feet, I found pieces of *mica schist* full of garnets, which seem to have come from the Grampian Hills to the north-west, showing that the transporting agent had overflowed even the highest parts of the Ochil ridge.

"On the Perthshire hills, between Blair-Athole and Dunkeld, I found ice-worn surfaces of rock on the tops of hills, at elevations of 2200 feet, as if caused by ice pressing over them from the north west, and *transported boulders* at even greater heights."

Referring to boulders in brick-clays, Mr Jamieson (p. 178) mentions that in "the Paisley brick-clay, which abounds in sea-shells (all of them Arctic), boulders of from 1 to 3 feet in length are not uncommon. I saw one 6 feet in length. Many of them show the glacial *striæ*. These boulders occur imbedded here and there at various depths. It is common to find a crust of *Balaní* attached to one of these boulders. It has generally been supposed that the *Balaní* are confined to the upper surface and sides of the stone, as if they had grown upon it after it had been dropped into its present position. I satisfied myself, however, that this is not always the case, for I found that *Balaní* do occasionally occur all over the lowermost side. For example, I observed one heavy stone,

measuring $32 \times 18 \times 14$ inches, imbedded in the clay about 15 feet from the surface. This boulder had not been moved out of its original position, and there were remains of *Balani* on various parts of the surface. I dug round it, and heaved it out of its bed, and found that the whole under side of it was covered with a close, thick crust of entire *Balani*, the points of which were sticking downwards into the soft clay beneath, showing clearly that they must have grown upon the stone, before it was dropped into its muddy bed. Other instances of the same kind were observed by me. I conclude, therefore, with regard to some of these boulders at least, that *Balani* grew on them before they came to be lodged in the clay (probably when they lay on some shore) and that afterwards they had got encrusted with ice, and being floated off, had dropped to the bottom when the ice about them melted."

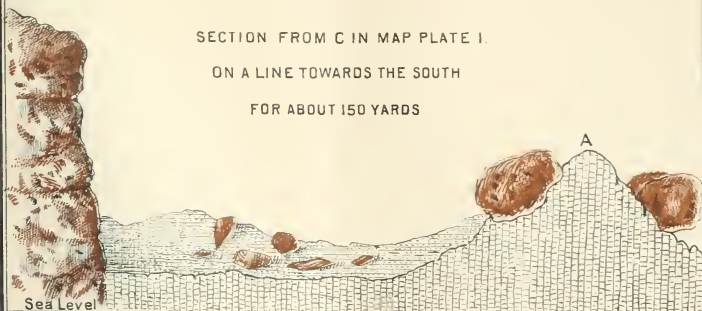
Mr Jamieson, in a footnote, adds—"I believe the species of *Balanus* on the under side of the boulder above-mentioned was *B. balanoides* of Darwin's monograph, which is a species that lives only between tide-marks. If this is correct, then, it could scarcely have grown on stones lying in water so deep as is indicated by the shells in this clay, and its presence could be explained only by some such theory as I have suggested. It would be an interesting fact should the *Balanus* on the upper surface prove to be of a deep-water species, and those on the lower of a tidal one."



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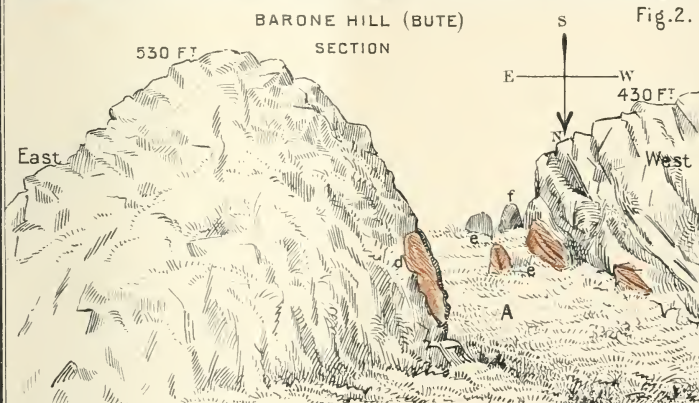
Fig.1.

SECTION FROM C IN MAP PLATE I.
ON A LINE TOWARDS THE SOUTH
FOR ABOUT 150 YARDS



BARONE HILL (BUTE)
SECTION

Fig.2.



GROUND PLAN /

Fig.3.

